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M. V. Andryukhova, PhD student (BSTU);
V. L. Fleisher, PhD (Engineering), assistant professor (BSTU);
T. V. Chernysheva, researcher (BSTU);
S. A. Gordeiko, PhD student (BSTU); **D. S. Makarov**, student (BSTU)

FUMARIC ACID AMIDES IN TECHNOLOGIES OF PAPER AND CARDBOARD

Fumaric acid polyamids were synthesized by interaction of fumaric acid with polyamines (diethylenetriamine, triethylenetetramine) by equilibrium polycondensation in the melt. The obtained products are promising as hardening additives in the technology of paper and cardboard.

This article studies the type and rate effects of fumaric acid polyamides on some paper strength properties (breaking length, breaking force in dry and wet states). It is shown that the greatest effect of the paper hardening is achieved by using the additive, which is a product of polycondensation of fumaric acid and diethylenetriamine.

Introduction. In the production of laminated paper and cardboard, various fiber intermediates, sizing materials, fillers, dyes hardening additives, electrolytes and cationic polyelectrolytes are used. The type and rate of each component affect paper-forming and colloid-chemical properties of this multicomponent system and depend on the requirements for the quality and cost of production [1].

At the current stage, the pulp and paper industry is trying to increase the consumption of waste paper, the use of which allows to solve not only economic, but also environmental problems [2]. However, the use of waste paper in the production of paper and cardboard requires the solution of a number of technological problems. One of the promising ways of their solutions is the use of hardening additives in the compositions of paper and cardboard. It is known that the use of polymer additives in the manufacture of paper improves the strength characteristics of the wet state and dry strength of molded paper. These are natural, partially modified or synthetic water-soluble polymers, such as cationic and anionic starches, sodium carboxymethyl cellulose, polyacrylamide, anionic polyacrylamide and low molecular weight cationic polymers such as Poly-DADMAC (diallildimethylammonium chloride) polyamideaminepichlorgidrin, poly-aminepichlorohydrine, polydicyandiamide [3].

On the base of the analysis of literature, it was suggested that the fumaric acid polyamides, resulting from their chemical structure, can be used in the technology of paper and cardboard as hardening additives.

Main part. The aim of this work was to obtain polyamides of fumaric acid by equilibrium polycondensation in the melt and to test obtained products in the technology of paper as hardening additives.Fumaric technical acid (FTA) I, diethylenetriamine (DETA) II and triethylenetetramine (TETA) III were used as starting materials. Fumaric acid IV, V, polyamides are formed according to the scheme. The reaction was performed in a three-necked 100 ml reactor equipped with a stirrer, a thermometer and a Dean – Stark with a refrigerator. 0.091 Mole of amine (I or II) was placed in the reactor and heated to 160°C, then 0.086 mole of fumaric acid(molar ratio of fumaric acid: amine was 1 : 1.05) was gradually introduced with stirring.

The reaction was monitored by the volume of released water, which determines the conversion of reactants (Fig. 1), as well as by changes in the acid number (AN) of the reaction mixture (Fig. 2). At the beginning of the reaction for the acid number was taken the value of the acid number of fumaric acid, which is 959.5 mg KOH/g scheme of fumaric acid polyamides (IV, V) formation (see p. 30).

The reaction resulted in obtaining dark brown soluble in water products.

IT was found that the reaction is occuring during the first 2–3 h, then the reaction rate slows down. To achieve maximum conversion of reagents it is advisible to carry out the final stage of synthesis under reduced pressure.

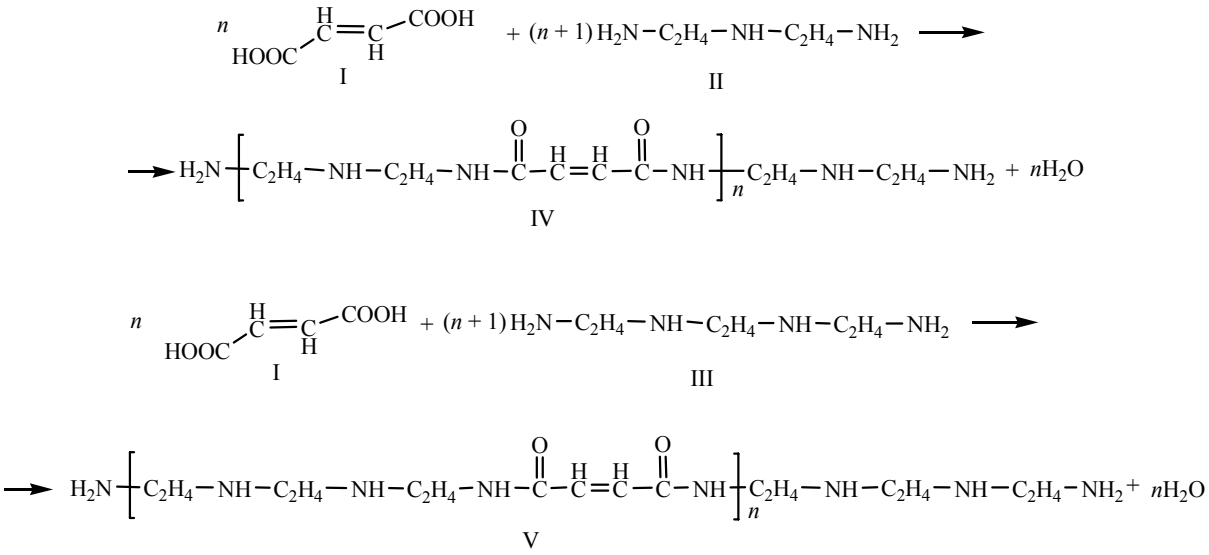
This will contribute to a shift of balance and the formation of polyamides in quantitative yield.

To evaluate the effectiveness of the hardening effect of the obtained fumaric acid polyamides in paper technology 2% solutions of products of interaction of the FTA with TETA (additive number 1) and the FTA with DETA (additive number 2) were prepared.

They were added to the pulp in the concentration of 0.5–2.0% of a. d. s. By comparison, a sample of paper without the additive was used.

Hardwood pulp, which was subjected to dissolution (mill NDM-3) and grinding (pulper LH-3) was used as the fibrous raw material.

Paper samples with a mass of 80 g per square meter were made from the resulting fiber suspension. The lengh and tensile breaking force in dry and wet states were determined. Testing of paper samples was performed according to SCAN P 38 meeting the requirements of DIN 53112. The breaking strength of paper samples in the dry state was determined on the horizontal tensile machine SE 062/064 of “Lorentzen and Wettre”.



Sheme of fumaric acid polyamides (IV, V) formation

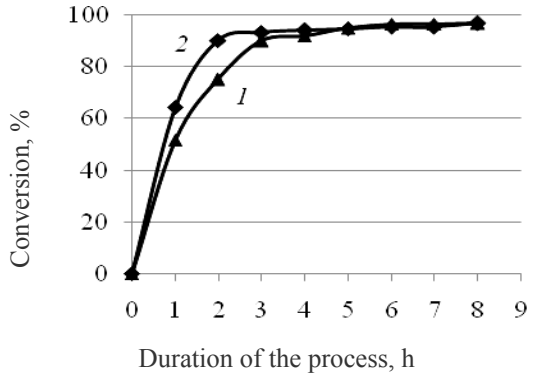


Fig. 1. Dependence of the conversion of reagents on the duration of the process of Interaction of FTA: *1* – with DETA, *2* – with TETA

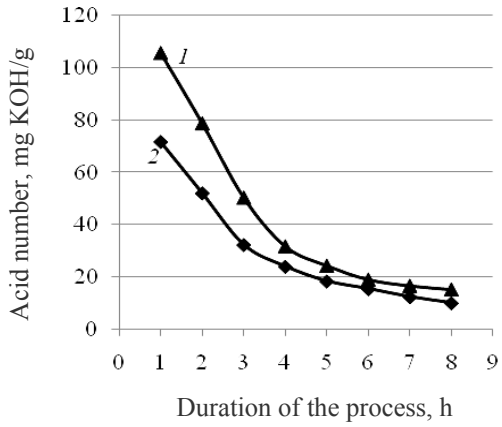


Fig. 2. Dependence of the change of acid number in the process of interaction of FTA: *1* – with DETA, *2* – with TETA

The dependence of the breaking length of paper samples on the type and rate of additive is shown in Fig. 3.

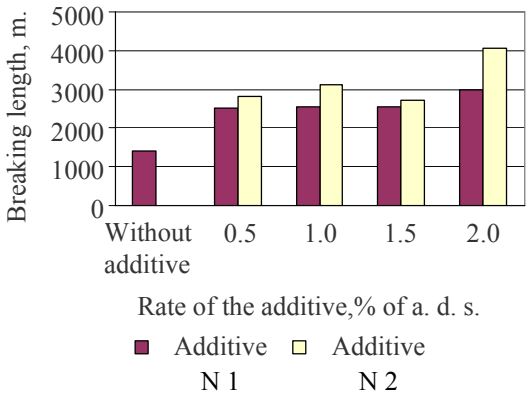


Fig. 3. Variation of the breaking length of paper depending on the type and rate of the additive

The analysis of the variation of the breaking length of paper samples depending on the type and rate of fumaric acid polyamides demonstrates the effectiveness of the reinforcement of both N 1 and N 2 additives over the entire range of rate.

Thus, the breaking length of paper samples increases from 2,524 to 2,982 m when the rate of additive N 1 increases from 0.5 to 2.0% of a. d. s. As for additive N 2 we have the increase of the breaking length from 2830 to 4054 m.

The data of the breaking force of paper samples in the dry and wet states with the addition of fumaric acid polyamides (Fig. 4, 5) also suggest an increase in the strength of paper samples.

Thus, with the inerease of the rate of additives N 1 and N 2 from 0.5 to 2% of a. d. s. the breaking force in the dry state increases from 2.55 to 3.40 kgf and from 2.90 to 4.20 kgf respectively. In the wet state with the increase of the rate of additives N 1 and N 2 from 0.5 to 2.0% of a. d. s. the breaking force increases from 0.07 to 0.10 kgf respectively.

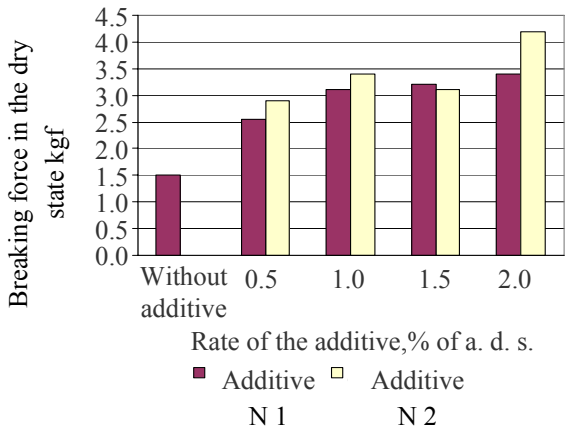


Fig. 4. Dependence of the breaking force of paper samples in the dry state on the type and rate of the additive

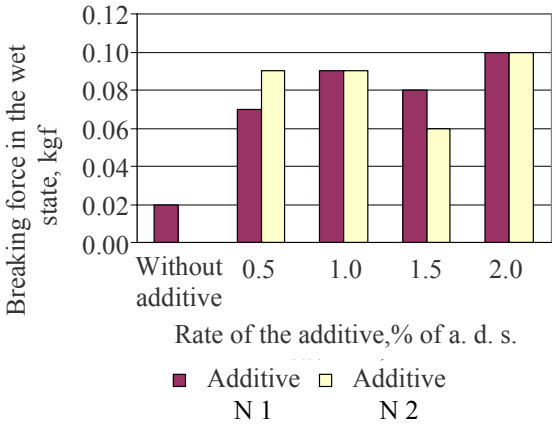


Fig. 5. Dependence of the breaking force of paper samples in the wet state on the type and rate of the additive

Conclusion. In this paper, the synthesis of fumaric acid polyamides by equilibrium polycondensation in the melt is accomplished. The type and rate effects of fumaric acid polyamides on the strength properties of paper are stated. It is shown that the greatest effect of the paper hardening is achieved by using additive N 2, which is a product of polycondensation of fumaric acid and diethylenetriamine.

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